DarkSide computing TDR

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Operating modes of detector

- **WIMP search mode**: most of the time. 88 Hz from ^{39}Ar β activity in TPC. Additional rate from SiPM dark counts: 40 Hz per each of the 2720 readout channels
- **Laser calibration mode**: PDM calibration by irradiating TPC with fibers in single-PE regime
- **Random trigger calibration mode**: unbiased PDM noise measurement and digitiser level hit finder efficiency
- **External calibration mode**: radioactive sources in calibration pipes or dissolved in LAr
- **Random waveform monitoring mode**: random acquisition of waveform chunks (length of single-PE signal, 5.6 μs))

Data streams

- Main stream (WIMP search mode) at about 60 MB/s
- Additional fast online event identification to control data throughput (selection, prescaling) and flag supernova candidates for SNEWS alerts (under investigation)

2. Data format

Context	Content type	Content
slice header	`int4`	slice start marker
slice header	`int4`	run type
slice header	`int20`	run number
slice header	`int4`	data quality flags
slice header	`int32`	slice ID
slice header	`int32`	timestamp
slice header	`int32`	slice end marker
slice header	`int32`	number of blocks in the slice
block specifier	`int16`	block element type
block specifier	`int16`	block element version
block specifier	`int32`	block element multiplicity
block specifier	`int32`	block element size

Context	Content type	Content
block specifier	$2 \times$ `int32`	TPC ZLE block specifier
block specifier	$2 \times$ `int32`	TPC hit block specifier
block specifier	$2 \times$ `int32`	IV hit block specifier
block specifier	$2 \times$ `int32`	OV hit block specifier
block specifier	$2 \times$ `int32`	sum of the top waveforms block specifier
block specifier	$2 \times$ `int32`	sum of the bottom waveforms block specifier

Context	Content type	Content
ZLE block	`/int16`	ZLE channel
ZLE block	`int16`	number of hits in ZLE
ZLE block	`float32`	ZLE time
ZLE block	`float32`	ZLE integral
ZLE block	`float32`	ZLE length
Hit block	`float32`	hit time
Hit block	`float32`	hit charge
Summed waveform block	$N_{samples} \times$ `float32`	sum of the top waveforms
Summed waveform block	$N_{samples} \times$ `float32`	sum of the bottom waveforms

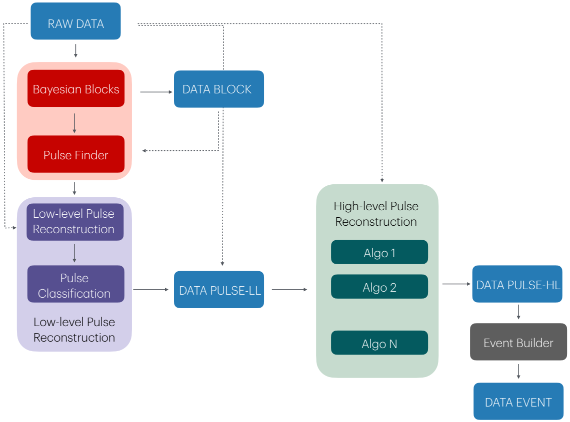
2. Data transfers

- Not that straightforward given LNGS location
- On paper:
  - Ad-hoc optical fiber connecting underground LNGS to surface, planned at 10 Gb/s
  - 10 Gb/s link from external LNGS facility to Italian GARR computing network ("soon" upgraded to 100 Gb/s)
  - Via GARR, 8–10 Gb/s connection to CNAF
- Real life tests: 2 Gb/s from external LNGS to CNAF
- Weak point: underground to external LNGS (not considered critical by labs...)
  $\Rightarrow$ underground storage buffer to stay offline for more that a week (100 TB)

3. Reconstruction

- Reconstruction: algorithms applied to raw data to derive nature (NR or ER), energy, topology, etc.
- Staged reconstruction planned (not fully ready yet) to speed up reprocessing

- Time slice = time series of PE-induced hits
- First step: Bayesian blocks (data chunks with constant rate)
- Second step: basic variables for "easy" pulse classification (number of hits, charge integration, prompt component)
- Refined reco: xy and z position, dealing with outliers
- Event building: association of scintillation and ionisation pulses



3. Computing resources

Task	CPU pledge (cores)	Disk	Tape
Raw data		20 PB	20 PB
Prompt data processing	100	75 TB	75 TB
Reprocessings	3000	300 TB	$<$ 1 PB
User analysis	300	300 TB	
MC simulation	500	2 PB	2 PB
Overall	1500	20 PB	20 PB

- Various assumptions, e.g. reprocessing of early stages every six months but turnaround of one week of refined reco in early stages, averaged to four months in TDR
- Includes dealing with calibration (2 weeks for ER, 36 days for NR)
- Considers that users will not analyse full 70 TB each time (event skimming/slimming), especially true as time goes on

  $\Rightarrow$ User analyses considered a minor contribution to computing resources

5. Simulation and 6. Databases

5. Simulation

- G4DS for tracking energy deposits and particle production
- Generation of scintillation signals (S1 full sim) in G4DS
- Generation of electroluminescence signal (S2) by fully tracking photons (G4DS, full-sim) or inferring light pattern for each energy deposit from light maps (dslab, fast-sim)
- Simulation of electronics response in PDM
- Reconstruction (as on real data)

6. Databases

- Storage of slow control, detector conditions, calibration constants, bookkeeping of data and simulation datasets, and of user jobs, authentication
- Not much detail yet

6. Data management/distribution/processing

- Data management: potentially rucio (from ATLAS originally)
- Distribution: CNAF foreseen. Decide this year if we could propose another site like CC-IN2P3
- Processing: considering DIRAC, or PanDA (from ATLAS originally)

7. Software

- Relies of python packages like numpy and dask, accelerated with high-performance just-in-time compilation with numba
- Analysis format: ROOT TTree
- Code managed in git, hosted at IN2P3 gitlab

Milestones

Milestone	When	Goal	Needs
M1: Offline data challenge	Dec 2024	Stress-test the pulse reconstruction with 10 h of simulated raw data	Pulse reconstruction software
M2: Release of computing TDR	Mar 2025	Provide final assessment of needed resources for DarkSide computing	Estimation of pulse and event reconstruction performance
Computing prototype	Mar 2025	Integrate simulation/reconstruction with prototype of data and workload management system	Data management and workload management pilots
M3: DAQ + offline data challenge	Jun 2025	Test integration of vertical slice and computing prototype	Vertical slice setup, computing prototype
M4: DAQ + offline + DBs data challenge	Dec 2025	Integrate computing system with its full input with the actual detector underground	DAQ operational underground at LNGS
M5: Commissioning	Dec 2026	Commissioning of the computing system with the sealed detector	Detector ready

Risks

Risk	Probability	Impact	Mitigation
Unavailability of data management system	Medium	High	Early implementation on the development phase, in sinergy with CNAF. Disk buffer at LNGS allows one week to fix transient issues.
Unavailability of workload management system	Low	Medium	Early implementation. Availability of full data on a single computing site (CNAF) allows to resort to temporary backup solution such as HTCondor.
Unavailability of detector databases	Medium	Medium	Can export DB fragments as dataset metadata.
Unavailability of authentication system	Low	Low	Backup credentials for central production
Storage corruption	Low	Medium	Redundancy of data copies (disk/tape)
Interruption of network connection to/from LNGS	High	High	Disk buffer on DAQ farm, DB replicas
Data format insufficient for detector characterization/physics	Medium	Low	Flexible raw data format. Support for schema evolution in raw and processed data formats.
Limited person power	High	High	Periodic user, developer and support team training. Shared documentation. Usage of GitOps/DevOps paradigms for automation